

1. A method of forming one or more fractures in a subterranean zone penetrated by a well bore and consolidating proppant particles therein comprising the steps of:

(a) providing proppant particles pre-coated with a coating composition comprising a hardenable organic resin, a silane coupling agent and a gel breaker;

(b) preparing or providing a gelled liquid fracturing fluid;

(c) pumping the gelled liquid fracturing fluid into the subterranean zone to form the one or more fractures therein;

(d) mixing the proppant particles pre-coated with the coating composition with the fracturing fluid pumped in accordance with step (c) whereby the pre-coated proppant particles are suspended therein;

(e) when the pre-coated proppant particles reach the one or more fractures, terminating the pumping of the fracturing fluid; and

(f) allowing the coating composition on the pre-coated proppant particles to harden by heat and consolidate the proppant particles into one or more permeable packs.

2. The method of claim 1 wherein the hardenable organic resin is selected from the group consisting of phenolic resin, furan resin, a mixture of phenolic and furan resin, a terpolymer of phenol, the reaction product of furfuryl alcohol with an aldehyde, resoles, resole/novolak mixtures, a bisphenol-aldehyde novolak polymer, a bisphenol homopolymer.

3. The method of claim 1 wherein the hardenable organic resin is a mixture of phenolic resin and furan resin.

4. The method of claim 1 wherein the hardenable organic resin is present in the coating composition in an amount in the range of from about 40% to about 70% by weight thereof.

5. The method of claim 1 wherein the silane coupling agent is selected from the group consisting of N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypyltrimethoxysilane and n-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane.

6. The method of claim 1 wherein the silane coupling agent is present in the hardenable resin composition in an amount in the range of from about 0.1% to about 3% by weight thereof.

7. The method of claim 1 wherein the gel breaker is selected from the group consisting of oxidative breakers, delayed release acids, delayed release enzymes, temperature activated breakers and hydrolyzable esters.

8. The method of claim 1 wherein the gel breaker is an oxidative breaker selected from the group consisting of organic peroxides, alkali metal persulfates and alkali metal chlorites, bromates, chlorates, hypochlorites and permanganates.

9. The method of claim 1 wherein the gel breaker is a delayed release acid breaker selected from the group consisting of acetic anhydride, fumic acid, benzoic acid, sulfonic acid, phosphoric acid, aliphatic polyesters, polylactic acid, polylactides, polyanhydrides, and polyamino acids.

10. The method of claim 1 wherein the gel breaker is a delayed release enzyme selected from the group consisting of alpha and beta amylases, exo- and endo-glucosidases,

amyloglucosidase, oligoglucosidase, invertase, maltase, cellulase, hemicellulase, endo-xylanase and exo-xylanase.

11. The method of claim 1 wherein the gel breaker is a temperature activated breaker selected from the group consisting of alkaline earth metal peroxides, zinc peroxides and mixtures thereof.

12. The method of claim 1 wherein the gel breaker is a hydrolyzable ester selected from the group consisting of sorbitol, catechol, dimethyl glutarate and a mixture of dimethyl glutarate, dimethyl succinate and dimethyl adipate.

13. The method of claim 1 wherein the gel breaker is dimethyl glutarate.

14. The method of claim 1 wherein the gel breaker is encapsulated in a water soluble encapsulating material.

15. The method of claim 1 wherein the gel breaker is encapsulated in an encapsulating material selected from the group consisting of polyvinyl alcohol, polylactic acid, EPDM rubber, polyvinylidene chloride, nylon, waxes, polyurethanes, cross-linked partially hydrolyzed acrylics and surfactants.

16. The method of claim 1 wherein the gel breaker is present in the coating composition in an amount in the range of from about 0.1% to about 10% by weight thereof.

17. The method of claim 1 wherein the gel breaker is added to the coating composition prior to coating the proppant particles.

18. The method of claim 1 wherein the gel breaker is added to the coating composition just after the particles have been coated with the hardenable organic resin and while the resin is still partially curing.

19. The method of claim 1 wherein the gel breaker is added to the coating composition as an outer layer after the particles have been coated with the hardenable organic resin and the resin has partially cured.

20. The method of claim 1 wherein the gel breaker is added to the coating composition as an outer layer at the well site just prior to pumping the pre-coated proppant particles down hole.

21. The method of claim 1 wherein the coating composition is pre-coated on the proppant particles in an amount ranging from about 0.1% to about 5% by weight of the proppant particles.

22. A method of forming one or more fractures in a subterranean zone penetrated by a well bore and consolidating proppant particles therein comprising the steps of:

(a) providing proppant particles pre-coated with a coating composition comprising a hardenable organic resin selected from the group consisting of phenolic resin, furan resin, a mixture of phenolic and furan resin, a terpolymer of phenol, the reaction product of furfuryl alcohol with an aldehyde, resoles, resole/novolak mixtures, a bisphenol-aldehyde novolak polymer, and a bisphenol homopolymer, a silane coupling agent and a gel breaker comprising dimethyl glutarate;

(b) preparing or providing a gelled liquid fracturing fluid;

(c) pumping the gelled liquid fracturing fluid into the subterranean zone to form the one or more fractures therein;

(d) mixing the proppant particles pre-coated with the coating composition with the fracturing fluid pumped in accordance with step (c) whereby the pre-coated proppant particles are suspended therein;

(e) when the pre-coated proppant particles reach the one or more fractures, terminating the pumping of the fracturing fluid; and

(f) allowing the coating composition on the pre-coated proppant particles to harden by heat and consolidate the proppant particles into one or more chemical and thermal degradation resistant permeable packs.

23. Pre-coated proppant particles comprising proppant particles coated with a coating composition comprising a hardenable organic resin, a silane coupling agent; and a gel breaker.

24. Pre-coated proppant particles of claim 23 wherein the hardenable organic resin is selected from the group consisting of a mixture of phenolic resin, furan resin, a mixture of phenolic and furan resin, a terpolymer of phenol, the reaction product of furfuryl alcohol and an aldehyde, resoles, resole/novolak mixtures, a bisphenol-aldehyde novolak polymer and a bisphenol homopolymer.

25. The pre-coated proppant particles of claim 23 wherein the hardenable organic resin is a mixture of phenolic and furan resin.

26. The pre-coated proppant particles of claim 23 wherein the hardenable organic resin is present in the coating composition in an amount in the range of from about 40% to about 70% by weight thereof.

27. The pre-coated proppant particles of claim 23 wherein the gel breaker is selected from the group consisting of oxidative breakers, delayed release acids, delayed release enzymes, temperature activated breakers and hydrolyzable esters.

28. The pre-coated proppant particles of claim 23 wherein the gel breaker is an oxidative breaker selected from the group consisting of organic peroxides, alkali metal persulfates and alkali metal chlorites, bromates, chlorates, hypochlorites and permanganates.

29. The pre-coated proppant particles of claim 23 wherein the gel breaker is a delayed release acid selected from the group consisting of acetic anhydride, fuming acid, benzoic acid, sulfonic acid, phosphoric acid, aliphatic polyesters, polylactic acid, polylactides, polyanhydrides, and polyamino acids.

30. The pre-coated proppant particles of claim 23 wherein the gel breaker is a delayed release enzyme selected from the group consisting of alpha and beta amylases, exo- and endo-glucosidases, amyloglucosidase, oligoglucosidase, invertase, maltase, cellulase, hemicellulase, endo-xylanase and exo-xylanase.

31. The pre-coated proppant particles of claim 23 wherein the gel breaker is a temperature activated breaker selected from the group consisting of alkaline earth metal peroxides, zinc peroxides and mixtures thereof.

32. The pre-coated proppant particles of claim 23 wherein the gel breaker is a hydrolyzable ester selected from the group consisting of sorbitol, catechol, dimethyl glutarate and a mixture of dimethyl glutarate, dimethyl succinate and dimethyl adipate.

33. The pre-coated proppant particles of claim 23 wherein the gel breaker is dimethyl glutarate.

34. The pre-coated proppant particles of claim 23 wherein the gel breaker is encapsulated in a water soluble encapsulating material.

35. The pre-coated proppant particles of claim 23 wherein the gel breaker is encapsulated in an encapsulating material selected from the group consisting of polyvinyl alcohol, polylactic acid, EPDM rubber, polyvinylidene chloride, nylon, waxes, polyurethanes, cross-linked partially hydrolyzed acrylics and surfactants.

36. The pre-coated proppant particles of claim 23 wherein the gel breaker is present in the coating composition in an amount in the range of from about 0.1% to about 10% by weight thereof.

37. The pre-coated proppant particles of claim 23 wherein the gel breaker is distributed within the hardenable resin composition.

38. The pre-coated proppant particles of claim 23 wherein the gel breaker is present as an outer layer of the hardenable resin composition.

39. A coating composition for coating proppant particles comprising:
a hardenable organic resin;
a silane coupling agent; and

a gel breaker.

40. The coating composition of claim 39 wherein the hardenable organic resin is selected from the group consisting of phenolic resin, furan resin, a mixture of phenolic and furan resin, a terpolymer of phenol, the reaction product of furfuryl alcohol with an aldehyde, resoles, resole/novolak mixtures, a bisphenol-aldehyde novolak polymer and a bisphenol homopolymer.

41. The coating composition of claim 39 wherein the hardenable organic resin is a mixture of phenolic resin and furan resin.

42. The coating composition of claim 39 wherein the hardenable organic resin is present in the coating composition in an amount in the range of from about 40% to about 70% by weight thereof.

43. The coating composition of claim 39 wherein the silane coupling agent is selected from the group consisting of N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane and n-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane.

44. The coating composition of claim 39 wherein the silane coupling agent is present in the composition in an amount in the range of from about 0.1% to about 3% by weight thereof.

45. The coating composition of claim 39 wherein the gel breaker is selected from the group consisting of oxidative breakers, delayed release acids, delayed release enzymes, temperature activated breakers and hydrolyzable esters.

46. The coating composition of claim 39 wherein the gel breaker is an oxidative breaker selected from the group consisting of organic peroxides, alkali metal persulfates and alkali metal chlorites, bromates, chlorates, hypochlorites and permanganates.

47. The coating composition of claim 39 wherein the gel breaker is a delayed release acid selected from the group consisting of acetic anhydride, fuming acid, benzoic acid, sulfonic acid, phosphoric acid, aliphatic polyesters, polylactic acid, polylactides, polyanhydrides, and polyamino acids.

48. The coating composition of claim 39 wherein the gel breaker is a delayed release enzyme selected from the group consisting of alpha and beta amylases, exo- and endo-glucosidases, amyloglucosidase, oligoglucosidase, invertase, maltase, cellulase, hemicellulase, endo-xylanase and exo-xylanase.

49. The coating composition of claim 39 wherein the gel breaker is a temperature activated breaker selected from the group consisting of alkaline earth metal peroxides, zinc peroxides and mixtures thereof.

50. The coating composition of claim 39 wherein the gel breaker is a hydrolyzable ester selected from the group consisting of sorbitol, catechol, dimethyl glutarate and a mixture of dimethyl glutarate, dimethyl succinate and dimethyl adipate.

51. The coating composition of claim 39 wherein the gel breaker is dimethyl glutarate.

52. The coating composition of claim 39 wherein the gel breaker is encapsulated in a water soluble encapsulating material.

53. The coating composition of claim 39 wherein the gel breaker is encapsulated in an encapsulating material selected from the group consisting of polyvinyl alcohol, polylactic acid, EPDM rubber, polyvinylidene chloride, nylon, waxes, polyurethanes, cross-linked partially hydrolyzed acrylics and surfactants.

54. The coating composition of claim 39 wherein the gel breaker is present in the coating composition in an amount in the range of from about 0.1% to about 10% by weight thereof.

55. The coating composition of claim 39 wherein the gel breaker is distributed within the coating composition.

56. The coating composition of claim 39 wherein the gel breaker is present as an outer layer of the coating composition.